Effects of Family, Friends, and Relative Prices on Fruit and Vegetable Consumption by African American Youths

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ABSTRACT

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Facilitating healthy eating among young people, particularly among minorities who are at high risk for gaining excess weight, is at the forefront of current policy discussions and food program reviews. We investigate the effects of social interactions and relative prices on fruit and vegetable consumption by African American youths using rich behavioral data from the Family and Community Health Study and area-specific food prices. We find the presence of endogenous effects between a youth and parent, but not between a youth and friend. Lower relative prices of fruits and vegetables tend to increase intakes. Results suggest that health interventions targeting a family member may be an effective way to increase fruit and vegetable intake by African Americans as a result of spillover consumption effects between the youths and parents.

Keywords: Social interactions, Healthy food choices, Fruit and vegetable consumption

JEL Codes: I12, J15, C35

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I. Introduction

Good nutrition in adolescence is key to positive growth and development early in life. Moreover, since dietary patterns formed during teenage years tend to persist into adulthood, adequate nutritional intake by young people sets the stage for maintaining good health later on.

Presently, eating habits of U.S. youths fall short of the federal Dietary Guidelines for Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). Health professionals are particularly alarmed by adolescents' tendency to consume lower amounts of fruits and vegetables than recommended (Task Force on Childhood Obesity, 2010), since the scientific literature indicates that fruit and vegetable intake may protect against cancer, provide benefits against other illnesses, and reduce the likelihood of gaining excess weight (Dietary Guidelines Advisory Committee, 2010). Given the staggering cost of treating obesity-related ailments (Finkelstein et al., 2009), and repercussions from the high prevalence of overweight among U.S. youths (Ogden et al., 2010) – such as a shortening of life expectancy (Olshansky et al., 2005), and reduction in the country's military readiness (Christeson et al., 2010) – shifting dietary patterns among young people toward "energy light" and "nutrient rich" foods such as fruits and vegetables has moved to the forefront of public policy discussions.

In this paper, we investigate determinants of fruit and vegetable consumption by African American youths. We exploit the richness of behavioral data collected by the Family and Community Health Study (FACHS) and area-specific food price data compiled by the Economic Research Service (ERS) of the U.S. Department of Agriculture to estimate the effects of fruit and vegetable consumption by an African American youth's parent and best friend and of relative food prices on the youth's own consumption. The results shed further light on factors underlying dietary choices of young people and guide recommendations for developing policy interventions to facilitate healthy eating. Doing so in the context of food consumption by African American youths is particularly important, because African Americans are at an elevated risk for gaining excess weight and having inadequate nutritional intake (Freedman et al., 2008; Ogden et al., 2010).[1]

This research contributes to the literature along two dimensions. First, we augment an economic framework in which individuals make decisions about specific foods to consume (Cawley, 2004) by explicitly allowing for impacts of social interactions (Manski, 1993) on a youth's food choice. Presence of social interactions is well established in the case of young people's substance use and abuse (e.g., Powell et al., 2005; Lundborg, 2006; Clark and Lohéac, 2007), as well as across other domains such as academic cheating (e.g., Carrell et al., 2008), welfare participation (e.g., Åslund and Fredriksson, 2009), and the spread of obesity (e.g., Christakis and Fowler, 2007; Renna et al., 2008; Trogdon et al., 2008). However, apart from suggestive qualitative evidence from focus group studies (e.g., Neumark-Sztainer et al., 1999) and limited quantitative evidence from small-scale experiments (e.g., Salvy et al., 2011), little is known about the effects of parental and peer eating habits on adolescents' healthy food choices. A better understanding of factors shaping dietary patterns is critical for developing programs to address poor nutrition, particularly because social interactions can amplify the effectiveness of health policy interventions. What is especially novel about our empirical approach is that the richness of behavioral data in the FACHS allows us to assess the impact of the parent's food consumption on the youth separately from the effect of the best friend's consumption. It is not possible to perform a similar analysis using the National Longitudinal Study of Adolescent Health (Add Health), a dataset often employed to study food consumption by adolescents (e.g., Videon and Manning, 2003; Stewart and Menning, 2009), because it does not contain information on parental eating habits.

Second, we contribute to the literature on the effects of food prices on health and nutrition. To date, much attention has been paid to the impact of food prices on body mass index (e.g., Chou et al., 2004; Auld and Powell, 2009). Substantial knowledge has also accu-

[1] For example, African Americans have the lowest intakes of fruits and vegetables among all main ethnic groups in the U.S. (Dietary Guidelines Advisory Committee, 2010, p. B3-1).

mulated on the magnitude of price effects on household food demand (see Unnevehr et al., 2010). We add to this body of research by evaluating whether individual consumption of fruits and vegetables by African Americans is sensitive to changes in the relative prices.

Our main estimation results are as follows. In the case of fruit, we detect the presence of statistically significant endogenous consumption effects between an African American youth and his or her parent, but not between the youth and friend. The effect of the relative fruit price on the fruit intake by the parent and friend is estimated to be negative and statistically significant. The price impact on the youth's intake is also negative but not significant. In the case of vegetables, we find a positive statistically significant impact of the parent's consumption on the youth's consumption, but we find no impact in the reverse direction and no apparent endogenous effects between the youth and friend. The relative vegetable price tends to have a statistically significant negative impact on the intake of vegetables by the youth and friend. The estimated price effect on the parent is not significant. Overall, the results suggest that among African American youths, eating habits are influenced more by the dietary choices of parents rather than by learning from food habits of friends.

The results imply that designing health policy interventions to increase fruit and vegetable consumption by only one family member such as, in particular, the mother – the most likely primary caregiver – may be an effective way to facilitate healthy food choices among African Americans, because increasing parental consumption of fruits and vegetables tends to have a "spillover" impact in the form of a higher intake of these foods by adolescent children. The estimates also suggest that decreasing the relative price of fruit (i.e., by subsidizing fruit) may raise the intake of fruit by parents of the youths and, because of the spillover effect, may increase fruit consumption by the youths themselves. Also, lowering the relative price of vegetables may increase their intake by the youths.

The remainder of this paper is organized as follows. In Section II, we provide details on the data used in the analysis. In Section III, we describe the theoretical framework, specify the econometric model, and outline the estimation approach. In Section IV, we present the estimation results. We conclude in Section V and relegate additional information to appendices.

II. Data

A. Family and Community Health Study (FACHS)

Our main data source is Wave 4 of the FACHS, which is an ongoing panel survey of African American youths, sponsored by the National Institutes of Health, designed to measure youths' health and development. The FACHS originated in 1997 as a survey of African American children between the ages of 10 and 12 and their immediate family members in Georgia and Iowa. In Georgia, respondents were recruited by community liaisons, who contacted families with children who met sampling criteria to determine their interest in participating. In Iowa, project staff obtained school rosters of students in grades four through six and invited families with children to participate. Wave 1 of the study, completed between January 1997 and June 1998, covered a sample of 897 families, of which 714 youth respondents were re-interviewed in Wave 4, which started in March 2005 and lasted until June 2007.

In Wave 4, the FACHS introduced a major expansion resulting from a grant from the Centers for Disease Control and Prevention (CDC). In particular, every youth respondent (in what follows, we refer to the youth respondent as the *youth*) was requested to name his or her best same-gender friend (*friend*). This friend participated in the study along with the youth's immediate family members, namely, the youth's primary caregiver (*parent*), second caregiver, and older sibling, if any.[2] This feature of Wave 4 makes it particularly suitable

[2]We use the term "parent" as a shortcut alternative to the FACHS term "primary caregiver," since 98.2% of the primary caregivers in our sample are either natural parents or parent-like figures. In particular, the primary caregiver is the mother of the youth in 86.4% of the cases. We do not use data on second caregivers and siblings, because the corresponding

to our research, because it provides us with data to disentangle the effect of friends, who are not immediate family members, from the effect of parents on food choices of the youths. In total, we have complete observations for 502 youth-friend-parent *triplets*. While data collection in Wave 4 was staggered over 28 months (i.e., March 2005 to June 2007, with the majority of data collected by August 2006), interviews with members of the same triplet were typically conducted either on the same day or within a short time frame. Each interview was conducted privately between one participant and one interviewer, with no other individuals present. Questions appeared in sequence on a laptop computer screen (responses to sensitive questions were collected using an accessory keypad).

B. Characteristics of FACHS Participants

Summary statistics for selected demographic and socioeconomic characteristics of individuals in our FACHS sample are provided in Table 1. As can be seen in Panel A, youths are between the ages of 17 and 22 and, on average, 19.3 years old. Forty two percent are male, and 96% identify themselves as African American (the rest mostly identify themselves as biracial).

In Panel B, we report characteristics of friends. In comparison to the youths, the age of the friends shows more variation, as they are between 14 and 52 years old. However, their average age is 19.9 years, which is only slightly higher than the average youth's age. Because of the Wave 4 restriction on the gender of the friends, the proportion of males among them is identical to the proportion of males among the youths (42%). In contrast, there is no restriction on the race of friends: 84% of them are African American, which is a lower proportion than among the youths.

In Panel C, we summarize characteristics of parents. They are between the ages of 33 and 89 and, on average, 45.1 years old. Eighteen percent have no high school degree, 34% have a high school degree or GED, 35% report one to three years of college education but no bachelor's or higher degree ("some college"), and 14% have a bachelor's or higher degree.

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sample sizes are small.

Table 1: Demographic and Socioeconomic Characteristics of FACHS Participants

Characteristic	Mean	Std. Dev.	Min	Max
Panel A: Youth				
Age in years	19.28	(0.83)	16.85	21.89
Indicator of male gender[a]	0.42	(0.49)	0	1
Indicator of African American race[b]	0.96	(0.20)	0	1
Panel B: Friend				
Age in years	19.87	(3.34)	13.54	51.59
Indicator of male gender[a]	0.42	(0.49)	0	1
Indicator of African American race[c]	0.84	(0.36)	0	1
Panel C: Parent				
Age in years	45.06	(7.68)	32.56	88.87
Indicator of male gender	0.05	(0.22)	0	1
Indicator of African American race[d]	0.92	(0.27)	0	1
Indicator of no high school degree[e]	0.18	(0.38)	0	1
Indicator of high school degree[e]	0.34	(0.47)	0	1
Indicator of some college education[e]	0.35	(0.48)	0	1
Indicator of bachelor's/higher degree[e]	0.14	(0.35)	0	1
Indicator of married parent	0.36	(0.48)	0	1
Indicator of poverty[f]	0.28	(0.45)	0	1

Notes: The number of youth-friend-parent triplets is 502.

[a]Youth and friend are always of the same gender by the FACHS Wave 4 design.

[b]Twenty two youths report a race other than African American: 18 identify themselves as biracial, 3 as Caucasian, and 1 as "other."

[c]Seventy eight friends report a race other than African American: 41 identify themselves as Caucasian, 24 as biracial, 4 as Asian, 4 as Latino, 3 as American Indian, and 2 as "other."

[d]Forty parents report a race other than African American: 31 identify themselves as Caucasian, 4 as Latino, 3 as biracial, and 2 as American Indian.

[e]Educational categories represent the highest level of educational attainment.

[f]Poverty status is imputed using household composition, income of family members, and official poverty thresholds.

Of parents, most are females (95%) and African American (92%); only 36% are married. We impute the poverty status of the parent's household using official poverty thresholds from the U.S. Bureau of Census and information on the household composition and income. The resulting incidence of poverty in our sample is 28%.

To investigate whether demographic and socioeconomic characteristics of our sample are in line with characteristics of the corresponding U.S. population, we performed a comparison of parents in the sample to a relevant subsample from the Current Population Survey (CPS). On the basis of the comparison (see Appendix A), we conclude that basic demographic characteristics are virtually identical in both cases, except that the proportion of married parents is lower in the FACHS. Also, parents in the FACHS tend to have less income and a somewhat lower educational attainment.

C. Fruit and Vegetable Consumption in FACHS

The youth, friend, and parent were asked two questions about their food choices in the week preceding the interview. First, they were asked to identify how often they ate fruit or drank fruit juice: *During the past seven days, how many times did you eat a whole piece of fruit (for example, an apple, orange or banana) or drink a glass of 100% fruit juice (do not count punch, Kool-Aid, or sports drinks)?*[3] Second, everyone reported the frequency of vegetable intake: *During the past seven days, how many times did you eat vegetables like green salad, carrots or potatoes (do not count French fries, fried potatoes, or potato chips)?* The answer categories for each question were (1) none, (2) less than once a day (1-6 times), (3) once a day, (4) 8-12 times, (5) twice a day (or more). Summary statistics for the answers are provided in Table 2. We use the reported "food frequency" as an indicator of the amount

[3]Combining consumption of whole fruit and 100% fruit juice is consistent with the definition of fruit consumption employed by the CDC (Centers for Disease Control and Prevention, 2010).

consumed.[4]

As can be inferred from Panel A of Table 2, approximately 61%, 60%, and 65% of the youths, friends, and parents, respectively, report consuming fruit at least once a day in the week preceding the interview, while non-negligible fractions of the youths (13%), friends (15%), and parents (11%) say they neither ate fruit nor drank fruit juice. Panel B reveals pronounced differences in the reported vegetable consumption between the youths and friends on the one hand, and parents on the other. In particular, 60% of the youths and 59% of friends report eating vegetables at least once a day, but the corresponding fraction among parents is much larger, at 76%. The difference is stark when we consider the incidence of no vegetable consumption (except possibly for fried potatoes and potato chips): 14% of the youths and 15% of friends say that they ate no vegetables in the last seven days, but the corresponding fraction of parents is a mere 3%.

Since the FACHS is not intended to be nationally representative, it is important to explore whether conclusions of our analysis using these data on African Americans from primarily Georgia and Iowa may apply to a broader population of African Americans in the U.S. In order to do that, we compare the reported fruit and vegetable consumption patterns of the FACHS participants to consumption patterns in relevant samples from the National Health and Nutrition Examination Survey (NHANES) 2005-2006, and find the difference between the patterns to be small (see Appendix B). Thus, the food consumption habits of the FACHS participants appear to be in line with the habits of the corresponding U.S. population.

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[4]Although the measurement error associated with reported food frequency may be substantial when the frequency is used to estimate usual dietary intake, Subar et al. (2006) find a positive and significant correlation between the food frequency measures and mean 24-hour intakes, especially for food groups.

Table 2: Fruit and Vegetable Consumption in FACHS

Answer	Youth, %	Friend, %	Parent,%
Panel A: During the past 7 days, how many times did you eat a whole piece of fruit or drink a glass of 100% fruit juice?			
(1) none	12.75	14.94	10.96
(2) less than once a day (1-6 times)	26.49	24.70	23.71
(3) once a day	30.48	30.88	40.24
(4) 8-12 times	11.55	8.37	6.77
(5) twice a day (or more)	18.73	21.12	18.33
Total	100.00	100.00	100.00
Panel B: During the past 7 days, how many times did you eat vegetables like green salad, carrots or potatoes?			
(1) none	13.75	14.94	3.19
(2) less than once a day (1-6 times)	26.10	26.29	20.52
(3) once a day	37.85	35.86	43.82
(4) 8-12 times	8.17	7.77	8.96
(5) twice a day (or more)	14.14	15.14	23.51
Total	100.00	100.00	100.00

Notes: The number of youth-friend-parent triplets is 502.

Fractions may not add up to 100% because of rounding.

D. Food Price Measures

We construct measures for fruit and vegetable prices using the ERS's Quarterly Food-at-Home Price Database (QFAHPD). This database contains quarterly prices (in dollars per 100 grams of food as purchased) for 52 separate food groups between 1999 and 2006 for 35 geographical market areas that cover the contiguous U.S. It is based on the Nielsen Homescan survey data, which include detailed information on purchases of barcoded and random-weight food items by a demographically balanced panel of metropolitan and nonmetropolitan households. The ERS aggregated the Homescan data into household-level quarterly prices for the food groups, and then aggregated the household-level prices into quarterly market-area food-group prices (Todd et al., 2010).

The QFAHPD has some advantages over other data sources such as a database maintained by the Council for Community and Economic Research (C2ER, formerly known as ACCRA).

Most notably, the QFAHPD contains separate prices for two groups of fruit (fresh/frozen whole fruit and canned whole fruit), one fruit juice group, and twelve vegetable groups.[5] Each food group price is based on a wide range of items purchased by households. Also, the QFAHPD incorporates food item purchases from all outlets, including grocery, drug, mass-merchandise, club, supercenter, and convenience stores. Thus, we believe that the QFAHPD is well suited for studying determinants of fruit and vegetable consumption. Importantly, this database allows us to exploit geographical and time variation in fruit and vegetable prices, likely to be largely driven by supply-side factors such as proximity and size of local markets and seasonality of agricultural production.

We construct price measures separately for fruits and vegetables. In the case of fruit, we first compute an index of quarterly fruit prices for each market area. It is an expenditure-weighted average of prices of the fruit and fruit juice groups in the QFAHPD (quarterly expenditures on each food group are available). Next, we calculate an index of all non-fruit prices (also specific to market area and quarter). Lastly, we obtain a relative fruit price as the ratio of the fruit index to non-fruit index. We compute a relative vegetable price analogously. Our focus on relative prices (rather than using several non-relative prices together in one specification) is motivated by model parsimony. Moreover, since our price variables are ratios of indices specific to market area and quarter, they account for market-area-specific price variation over time while eliminating the confounding effects of inflation. The results are robust to inclusion of "raw" fruit and vegetable price measures in place of the relative ones (see Appendix C).

We merged the price variables with the FACHS records using information on the ZIP

[5]The twelve vegetable groups are as follows: fresh/frozen dark green vegetables, canned dark green vegetables, fresh/frozen orange vegetables, canned orange vegetables, fresh/frozen starchy vegetables, canned starchy vegetables, fresh/frozen other-nutrient dense vegetables, canned other-nutrient dense vegetables, fresh/frozen other-mostly water vegetables, canned other-mostly water vegetables, fresh/frozen/dried legumes, and canned/processed legumes.

code of residence and interview date. The respondents face fruit prices with a mean value of 0.46 (minimum of 0.38 and maximum of 0.53). The mean value estimate indicates that the cost of 100 grams of fruit constitutes, on average, 46% of the cost of 100 grams of other foods. In turn, the relative prices of vegetables vary from 0.42 to 0.57 with a mean value of 0.48, indicating that vegetables cost, on average, 48% of the price of other foods (by weight).[6]

III. Empirical Model

A. *Theoretical Framework*

Our empirical analysis is based on a standard economic framework in which an individual maximizes his or her utility by engaging in behaviors related to work, leisure, home production, production of health, and consumption of foods and other goods (Cawley, 2004). Food consumption affects utility directly through the enjoyment of eating meals and entertainment provided by dining with family and friends (Chou et al., 2004, p. 570). It also has an indirect impact on utility through the effect of the diet on health. The individual makes his or her decisions subject to a budget constraint, which is affected by income and prices, a time constraint, and constraints imposed by biology. Outcomes such as a mix of consumed foods are derived based on marginal costs and benefits. Changes in relative prices of different foods are expected to affect the demand for them.

[6] Out of all 1,506 respondents in our sample, 18 individuals were interviewed in the first and second quarters of 2007 (the rest were interviewed in 2005 or 2006). Because the available QFAHPD data for 2007 are not comparable to prior years, we merged these 18 records with prices for the fourth quarter of 2006. To check the robustness of the results, we additionally estimated empirical models while excluding these records from the sample. The exclusion had no impact on the results (see Appendix C). Also, in 63 cases, a triplet member resided in a different market area than others. We decided not to drop these records in order to preserve the available data variation.

We augment this framework by allowing for social interactions. Social interactions acknowledge that the utility from a given action can depend directly on the choices, and possibly characteristics of others in the individual's reference group (e.g., family, friends, or coworkers), as opposed to the dependence that arises solely through the intermediation of markets (Brock and Durlauf, 2001). Thus, food consumption by the individual can depend not only on prices and the individual's own characteristics, but also on food choices, and possibly characteristics of his or her reference group members (e.g., education of parents).

In the literature, the impact of the behavior of others in the reference group on the individual's own behavior is known as the *endogenous effect*, while the impact of the characteristics of others is referred to as the *contextual effect* (Manski, 1993). Observable interdependence among the behaviors may also arise because of the *correlated effect*. Moffitt (2001) makes a useful distinction between its two sources. First, sorting may force individuals with similar unobservable preferences to be grouped together. Second, all reference group members may be affected by a common unobservable factor. Distinguishing among these various effects is crucial for designing public health policies, because the endogenous effect is associated with a social multiplier, which can amplify the effectiveness of policy interventions. In contrast, the contextual effect does not generate a multiplier and indicates the need for a different intervention design. In turn, the correlated effect means that neither behaviors nor characteristics of the reference group members have a causal impact on the individual's own behavior.

Identification of social interactions is a challenging econometric task, and active research in this area is still ongoing (e.g., Bramoullé et al., 2009). In our empirical model, we explicitly allow for endogenous effects and follow a standard practice of restricting some (but not all) contextual effects (e.g., Powell et al., 2005; Krauth, 2006; Lundborg, 2006; Carrell et al., 2008; Trogdon et al., 2008). The endogenous effects are allowed to be asymmetric across individuals (e.g., Harris and López-Valcárcel, 2008). We account for the correlated effect by explicitly allowing for unobservable determinants of food behaviors (e.g., unobservable food preferences) to be correlated within a youth-friend-parent triplet. In doing so, we follow an approach of Evans et al. (1992) and, more recently, Krauth (2006), who explicitly allows for correlated error terms within an individual's reference group to account for the correlated effect. Unlike Krauth (2006), however, we do not restrict the correlations within the triplet to the same value, but rather we allow for potentially different correlations (e.g., the correlation coefficient between a youth's and his or her parent's "errors" can be different from the correlation coefficient between the youth's and best friend's errors).

B. Econometric Model

We denote a generic youth, friend, and parent by Y, F, and P respectively, and use these symbols in subscripts and variable names. The Y-F-P triplets are indexed by t, $t = 1, 2, ..., T$, where T is the number of triplets in the sample ($T = 502$).

We are interested in explaining *consumption* of fruits and vegetables rather than the *number of times* someone ate them in the past week (Table 2). This number is only a proxy for unobservable consumption, which could potentially be measured in food weight, calories, or other units. To account for this potential data limitation, we employ latent variables (for a justification of this methodological approach, see Cameron and Trivedi, 1986, p. 49). We propose a simultaneous equation model that is an extension of the model of Maddala and Lee (1976) to a setting with ordered responses. The model is described below for the case of fruit consumption. Its specification for vegetable consumption is analogous. We do not combine fruit consumption and vegetable consumption together in order to preserve the available variation in the data. To the best of our knowledge, the model is novel in that it considers social interactions in a multivariate ordered probit setting.

Let $w^*_{Y,t}$ be a latent continuous variable that reflects consumption of fruit by Y from triplet t. Instead of $w^*_{Y,t}$, we observe a categorical answer $w_{Y,t}$ about the frequency of Y's consumption in the past week, namely, (1) none, (2) less than once a day (1-6 times), (3) once a day, (4) 8-12 times, or (5) twice a day (or more). For example, if Y reports having consumed fruit once a day, $w_{Y,t} = 3$. We assume that a particular value of $w_{Y,t}$ is observed whenever $w^*_{Y,t}$ falls between corresponding thresholds:

$$w_{Y,t} = j \text{ if and only if } \alpha_Y(j) < w^*_{Y,t} \leq \alpha_Y(j+1) \text{ for } j = 1, 2..., 5,$$

where the thresholds $\alpha_Y(1), \alpha_Y(2) ..., \alpha_Y(6)$ are six real constants such that $-\infty = \alpha_Y(1) \leq \alpha_Y(2) \leq ... \leq \alpha_Y(6) = +\infty$. We define latent variables $w^*_{F,t}$ and $w^*_{P,t}$, observed categorical answers $w_{F,t}$ and $w_{P,t}$, and thresholds $\alpha_F(1), ..., \alpha_F(6)$ and $\alpha_P(1), ..., \alpha_P(6)$ analogously.

Let a $k \times 1$ vector of characteristics of triplet t be denoted by $\mathbf{x}_t$. This vector includes a constant term and variables created from the demographic and socioeconomic characteristics of the FACHS participants (Table 1) and food prices (we implicitly treat every individual as a price taker). Given random sampling of families in the survey, we assume that the vector of the observed data $(w_{Y,t}, w_{F,t}, w_{P,t}, \mathbf{x}'_t)'$ is independent and identically distributed (i.i.d.) across t (dependence within a given t is not ruled out, however). To facilitate further discussion, let a $k_Y \times 1$ vector $\mathbf{x}_{Y,t}$ be a subset of $\mathbf{x}_t$ specific to Y (in a sense to become self-evident shortly). Similarly, a $k_F \times 1$ vector $\mathbf{x}_{F,t}$ and $k_P \times 1$ vector $\mathbf{x}_{P,t}$ are subsets of $\mathbf{x}_t$ specific to F and P, respectively. In Table 3, we list all variables comprising $\mathbf{x}_t$ and indicate with "$\surd$" which vector – $\mathbf{x}_{Y,t}$, $\mathbf{x}_{F,t}$, or $\mathbf{x}_{P,t}$ – contains a particular variable (an explanation for the specification choice is provided shortly). Note that $\mathbf{x}_t$ does not contain body mass index (BMI) and individual income, since they may be endogenous with respect to food choice behavior.[7] Also, observe that $\mathbf{x}_t$ does not contain place of residence and seasonal indicators, because including them would leave substantially less variation in the prices for us to identify relative price effects (for a similar approach, see Auld and Powell, 2009).

The model comprises three equations parameterized as follows:

$$\begin{aligned} w^*_{Y,t} &= w^*_{F,t} \cdot \gamma_{FY} + w^*_{P,t} \cdot \gamma_{PY} + \mathbf{x}'_{Y,t} \cdot \boldsymbol{\beta}_Y + \epsilon_{Y,t}, \\ w^*_{F,t} &= w^*_{Y,t} \cdot \gamma_{YF} + \mathbf{x}'_{F,t} \cdot \boldsymbol{\beta}_F + \epsilon_{F,t}, \\ w^*_{P,t} &= w^*_{Y,t} \cdot \gamma_{YP} + \mathbf{x}'_{P,t} \cdot \boldsymbol{\beta}_P + \epsilon_{P,t}. \end{aligned} \tag{1}$$

[7]We believe that parental/household poverty status, which is included as an explanatory variable, is less problematic since it is computed using income of all family members.

Table 3: Explanatory Variables

Variable in $\mathbf{x}_t$	$\mathbf{x}_{Y,t}$	$\mathbf{x}_{F,t}$	$\mathbf{x}_{P,t}$	Description
constant	$\surd$	$\surd$	$\surd$	Constant term
Y_age	$\surd$			Age of Y
Y_age2	$\surd$			Age squared of Y
Y_male[a]	$\surd$	$\surd$		Indicator of male gender of Y
F_age		$\surd$		Age of F
F_age2		$\surd$		Age squared of F
F_black		$\surd$		Indicator of African American race of F
P_age			$\surd$	Age of P
P_age2			$\surd$	Age squared of P
P_higher_educ[b]	$\surd$		$\surd$	Indicator of college education of P (with or without degree)
P_married	$\surd$		$\surd$	Indicator of married P
P_poverty	$\surd$		$\surd$	Indicator of P in poverty
relative_price[c]	$\surd$	$\surd$	$\surd$	Relative fruit price
	$k_Y = 8$	$k_F = 6$	$k_P = 7$	

Notes: [a]Y and F are always of the same gender by the FACHS Wave 4 design.

[b]The omitted education category comprises P's with a high school degree or less.

[c]The price variable is specific to place of residence and interview date.

In the system (1), parameter γ_{FY} measures an endogenous effect of fruit consumption by F from triplet t, $w^*_{F,t}$, on the consumption of fruit by Y from the same triplet, $w^*_{Y,t}$. Parameters γ_{PY}, γ_{YF}, and γ_{YP} have similar meaning. To derive a reduced form for the system (see Subsection C.), we assume that these parameters satisfy an inequality $\gamma_{PY} \cdot \gamma_{YP} + \gamma_{FY} \cdot \gamma_{YF} \neq 1$.

Next, a $k_Y \times 1$ vector $\boldsymbol{\beta}_Y$ represents parameters measuring a "structural" effect of $\mathbf{x}_{Y,t}$ on $w^*_{Y,t}$ given fixed $w^*_{F,t}$ and $w^*_{P,t}$. To avoid ambiguity, it is worth pointing out that in the simultaneous equation system (1), the effect of $\mathbf{x}_{Y,t}$ on $w^*_{Y,t}$ (i.e., given fixed $w^*_{F,t}$ and $w^*_{P,t}$) need not coincide with a "reduced-form" effect of $\mathbf{x}_{Y,t}$ on $w^*_{Y,t}$. Likewise, a $k_F \times 1$ vector $\boldsymbol{\beta}_F$ and $k_P \times 1$ vector $\boldsymbol{\beta}_P$ measure structural effects.

Lastly, an error term $\epsilon_{Y,t}$ represents the effect of unobservable variables (e.g., unobservable food tastes of Y) on $w^*_{Y,t}$. Error terms $\epsilon_{F,t}$ and $\epsilon_{P,t}$ have similar meaning. We assume that the vector $(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t})'$ is i.i.d. across t conditional on $\mathbf{x}_t$ as a mean zero normal random vector:

$$(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t})' \,|\mathbf{x}_t \sim N(\mathbf{0}, \mathbf{\Sigma}), \qquad (2)$$

where $\mathbf{\Sigma}$ is the covariance matrix. Thus, for a given t, we allow $\epsilon_{Y,t}$, $\epsilon_{F,t}$, and $\epsilon_{P,t}$ to be correlated with each other (e.g., members of the same triplet can have similar unobservable food preferences), but we do not restrict the corresponding correlation coefficients to have the same value. The assumption of normality is imposed as a practical consideration for us to be able to estimate the model.

The system (1) may be interpreted as an approximation to a demand system that incorporates (possibly, asymmetric) social interactions between Y and F and between Y and P. Several behavioral mechanisms may underlie these interactions. For example, since Y considers F to be his or her best friend, they may share many experiences and perceptions (good or bad) with each other. The shared perceptions about foods would include preferences for fruits and vegetables. Also, Y and F may occasionally eat together, in which case the interdependence of their food consumption behaviors may result from one of them "mimicking" the other. Similar mechanisms may underlie the endogenous effects between Y and P, because Y and P are likely to communicate on a regular basis and often eat together.[8] In contrast, since the extent of exposure of F and P to each other's food choices is limited, we rule out endogenous effects between them. In fact, less than 30% of parents in our sample report that they know the youth's friends very well in the first place, let alone what specific foods the friends prefer to eat.

In addition, the model incorporates effects on fruit consumption by an individual of his or her own age in the cases of Y, F, and P,[9] of gender in the cases of Y and F, and of

[8]It may be that the diets of many youths in our sample are, to a large degree, determined by their parents' food purchasing decisions. It is also possible that a youth's food preferences affect his or her parent's preferences and vice versa.

[9]We include second-order polynomials in age to account for possibly nonlinear effects. The

race in the case of F. Allowing for one's own age, gender, and race to affect food intake is in line with prior research (e.g., Videon and Manning, 2003; Stewart and Menning, 2009), but we are unable to include a full range of such effects. In particular, since Y and F are always of the same gender by the survey design, the effects of their genders are not separately identifiable (thus, $\mathbf{x}_{Y,t}$ and $\mathbf{x}_{F,t}$ contain the same variable Y_male). Also, we do not include indicators for the race of Y and race or gender of P because few youths in the sample are not African American, and few parents are not African American or are male and hence the corresponding effects would be difficult to identify.

We include the contextual effects of parental education, marital status, and poverty as these variables may be indicative of the impact of parental human capital (e.g., knowledge about life-long health benefits conferred by a healthy diet) and of household resources on the incidence of healthy eating within a given family. In particular, more educated parents may have better knowledge of the benefits of fruit consumption and may communicate this knowledge directly to their children. Thus, education of P may affect food preferences of Y. In addition, since more educated parents tend to have higher incomes, P's education may affect Y's budget constraint if there are intra-family transfers. Marital status and poverty may have similar, resource-related effects. Thus, we include the corresponding indicators in both $\mathbf{x}_{Y,t}$ and $\mathbf{x}_{P,t}$. We follow a standard practice in the literature by suppressing all other contextual effects (e.g., Powell et al., 2005; Krauth, 2006; Lundborg, 2006; Carrell et al., 2008; Trogdon et al., 2008).

C. Estimation Strategy

Since the dependent variables $w^*_{Y,t}$, $w^*_{F,t}$, and $w^*_{P,t}$ are observed only ordinally, variances of the errors $\epsilon_{Y,t}$, $\epsilon_{F,t}$, and $\epsilon_{P,t}$ are impossible to identify (Maddala, 1983, p. 47). Therefore, we specify the covariance matrix of the errors as

robustness of the results to the exclusion of quadratic age terms is discussed in Appendix C.

$$\mathbf{\Sigma} = \begin{pmatrix} 1 & \rho_{YF} & \rho_{YP} \\ \rho_{YF} & 1 & \rho_{FP} \\ \rho_{YP} & \rho_{FP} & 1 \end{pmatrix}, \tag{3}$$

where each diagonal entry is normalized to one and parameters ρ_{YF}, ρ_{YP}, and ρ_{FP} are correlation coefficients to estimate. We must also impose a normalization on the thresholds:

$$\alpha_Y(2) = \alpha_F(2) = \alpha_P(2) = 0, \tag{4}$$

which leaves a total of nine thresholds, $\{\alpha_Y(j), \alpha_F(j), \alpha_P(j)\}_{j=3}^{5}$, to estimate. Then, the identification approach is analogous to a textbook approach for a system of linear equations (for an explanation of why the analogy holds, see Maddala and Lee, 1976, pp. 531-533). Given the restrictions discussed earlier, the model is identified using formal identification conditions for simultaneous equation systems (Greene, 2008, pp. 368-369).

We rewrite the system (1) in a matrix form:

$$\left(w_{Y,t}^{*}, w_{F,t}^{*}, w_{P,t}^{*}\right) \cdot \mathbf{\Gamma} + \mathbf{x}_t' \cdot \mathbf{B} = \left(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}\right), \tag{5}$$

where a $k \times 3$ matrix $\mathbf{B}$ consists of zeros and elements of the vectors $-\boldsymbol{\beta}_Y$, $-\boldsymbol{\beta}_F$, and $-\boldsymbol{\beta}_P$ that are arranged according to the layout in Table 3 and a 3×3 matrix $\mathbf{\Gamma}$ is

$$\mathbf{\Gamma} = \begin{pmatrix} 1 & -\gamma_{YF} & -\gamma_{YP} \\ -\gamma_{FY} & 1 & 0 \\ -\gamma_{PY} & 0 & 1 \end{pmatrix}.$$

Given the assumption that $\gamma_{PY} \cdot \gamma_{YP} + \gamma_{FY} \cdot \gamma_{YF} \neq 1$, matrix $\mathbf{\Gamma}$ is nonsingular, and we can solve for the reduced form of the system (5) as

$$\left(w_{Y,t}^{*}, w_{F,t}^{*}, w_{P,t}^{*}\right) = \mathbf{x}_t' \cdot \mathbf{\Pi} + \left(v_{Y,t}, v_{F,t}, v_{P,t}\right), \tag{6}$$

where a $k \times 3$ matrix $\mathbf{\Pi} = -\mathbf{B} \cdot \mathbf{\Gamma}^{-1}$ and a 1×3 vector of the reduced form errors $\left(v_{Y,t}, v_{F,t}, v_{P,t}\right) = \left(\epsilon_{Y,t}, \epsilon_{F,t}, \epsilon_{P,t}\right) \cdot \mathbf{\Gamma}^{-1}$ is i.i.d. across t conditional on $\mathbf{x}_t$ as a mean zero normal random vector:

$$(v_{Y,t}, v_{F,t}, v_{P,t})' \,|\mathbf{x}_t \sim N(\mathbf{0}, \mathbf{\Omega}), \tag{7}$$

where $\mathbf{\Omega} = \left(\mathbf{\Gamma}^{-1}\right)' \cdot \mathbf{\Sigma} \cdot \mathbf{\Gamma}^{-1}$ is the covariance matrix.

We estimate the model using the maximum likelihood method. The likelihood contribution of a triplet is the probability of observing actual answers about fruit consumption by all three triplet members (Y, F, and P). We derive this probability using the reduced form (6) and joint distribution (7) of the reduced form errors. Let $\boldsymbol{\theta}$ be a vector of all identifiable parameters of the model:

$$\boldsymbol{\theta} = \left(\{\alpha_Y(j), \alpha_F(j), \alpha_P(j)\}_{j=3}^{5}, \rho_{YF}, \rho_{YP}, \rho_{FP}, \gamma_{FY}, \gamma_{PY}, \gamma_{YF}, \gamma_{YP}, \boldsymbol{\beta}'_Y, \boldsymbol{\beta}'_F, \boldsymbol{\beta}'_P\right)'.$$

The parameters of the reduced form, matrices $\mathbf{\Pi}$ and $\mathbf{\Omega}$, are known functions of $\boldsymbol{\theta}$. We partition $\mathbf{\Pi}$ as $\mathbf{\Pi} = [\boldsymbol{\pi}_Y, \boldsymbol{\pi}_F, \boldsymbol{\pi}_P]$, where the three $k \times 1$ vectors $\boldsymbol{\pi}_Y$, $\boldsymbol{\pi}_F$, and $\boldsymbol{\pi}_P$ are also known functions of $\boldsymbol{\theta}$. Then, the likelihood contribution of triplet t is

$$L_t(\boldsymbol{\theta}) \equiv L(w_{Y,t}, w_{F,t}, w_{P,t}|\mathbf{x}_t; \boldsymbol{\theta}) = \Pr\left[\alpha_Y(w_{Y,t}) < w^*_{Y,t} \leq \alpha_Y(w_{Y,t}+1),\right. \tag{8}$$

$$\left.\alpha_F(w_{F,t}) < w^*_{F,t} \leq \alpha_F(w_{F,t}+1), \alpha_P(w_{P,t}) < w^*_{P,t} \leq \alpha_P(w_{P,t}+1)\,|\mathbf{x}_t; \boldsymbol{\theta}\right] =$$

$$= \Pr[\alpha_Y(w_{Y,t}) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_Y < v_{Y,t} \leq \alpha_Y(w_{Y,t}+1) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_Y,$$

$$\alpha_F(w_{F,t}) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_F < v_{F,t} \leq \alpha_F(w_{F,t}+1) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_F,$$

$$\alpha_P(w_{P,t}) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_P < v_{P,t} \leq \alpha_P(w_{P,t}+1) - \mathbf{x}'_t \cdot \boldsymbol{\pi}_P|\mathbf{x}_t; \boldsymbol{\theta}] =$$

$$= \int\limits_{\alpha_Y(w_{Y,t})-\mathbf{x}'_t\boldsymbol{\pi}_Y}^{\alpha_Y(w_{Y,t}+1)-\mathbf{x}'_t\boldsymbol{\pi}_Y} \int\limits_{\alpha_F(w_{F,t})-\mathbf{x}'_t\boldsymbol{\pi}_F}^{\alpha_F(w_{F,t}+1)-\mathbf{x}'_t\boldsymbol{\pi}_F} \int\limits_{\alpha_P(w_{P,t})-\mathbf{x}'_t\boldsymbol{\pi}_P}^{\alpha_P(w_{P,t}+1)-\mathbf{x}'_t\boldsymbol{\pi}_P} f(v_{Y,t}, v_{F,t}, v_{P,t}|\mathbf{x}_t; \boldsymbol{\theta})\, dv_{P,t} dv_{F,t} dv_{Y,t},$$

where $f(v_{Y,t}, v_{F,t}, v_{P,t}|\mathbf{x}_t; \boldsymbol{\theta})$ is a trivariate normal density function, as implied by (7).

Computation of $L_t(\boldsymbol{\theta})$ in (8) requires evaluating a trivariate normal rectangle probability. This evaluation problem was extensively studied in the literature, and numerical algorithms are available (see Genz, 2004). Thus, we can obtain an estimate of $\boldsymbol{\theta}$ by the maximum likelihood method as

$$\widehat{\boldsymbol{\theta}}_{MLE} = \arg\max_{\boldsymbol{\theta}} \sum_{t=1}^{T} \ln L_t(\boldsymbol{\theta})$$

and conduct statistical inference using standard techniques (e.g., Greene, 2008, Ch. 16).

IV. Results

A. Fruit Consumption

The estimated model of fruit consumption is presented in Table 4. In Panel A, we list estimates of the thresholds (there are three identifiable thresholds for each triplet member). Panel B provides estimates of the endogenous effects. Panel C contains estimates of the effects of the explanatory variables. Estimates of the correlations among the error terms are given in the notes to the table.[10]

We arrange the estimates in columns corresponding to the three equations of the system (1) and in line with the layout in Table 3. Note that while the thresholds are an essential component of the econometric model and Panel A shows that all of them are precisely estimated, we are primarily interested in coefficients in Panels B and C.

Panel B reveals the presence of endogenous effects in the consumption of fruit. More specifically, we estimate a statistically significant positive impact of the parent's consumption on the youth's consumption ($\widehat{\gamma}_{PY} = 0.620$) and of the youth's consumption on the parent's consumption ($\widehat{\gamma}_{YP} = 0.382$). We do not detect the presence of endogenous effects between

[10]To ensure that the positive definiteness of the normalized matrix of the errors and the constraints imposed on the thresholds were true, we reparameterized the model prior to estimation. All estimates were obtained by numerically maximizing the sample log-likelihood function, and standard errors were computed using outer products of numerical gradients of the log-likelihood contributions (Berndt et al., 1974). We then recovered estimates of the original parameters and computed corresponding standard errors by the delta method (Greene, 2008, pp. 1055-1056).

Table 4: Estimated Model of Fruit Consumption

	Youth: $w^*_{Y,t}$ Coeff.	Std. Err.		Friend: $w^*_{F,t}$ Coeff.	Std. Err.		Parent: $w^*_{P,t}$ Coeff.	Std. Err.
Panel A: Thresholds								
$\widehat{\alpha}_Y\,(3)$	0.753**	(0.101)	$\widehat{\alpha}_F\,(3)$	0.764**	(0.074)	$\widehat{\alpha}_P\,(3)$	0.861**	(0.078)
$\widehat{\alpha}_Y\,(4)$	1.442**	(0.172)	$\widehat{\alpha}_F\,(4)$	1.546**	(0.111)	$\widehat{\alpha}_P\,(4)$	1.946**	(0.109)
$\widehat{\alpha}_Y\,(5)$	1.766**	(0.207)	$\widehat{\alpha}_F\,(5)$	1.801**	(0.124)	$\widehat{\alpha}_P\,(5)$	2.181**	(0.118)
Panel B: Endogenous Effects								
$\widehat{\gamma}_{FY}$	0.285	(0.182)	$\widehat{\gamma}_{YF}$	−0.251	(0.243)	$\widehat{\gamma}_{YP}$	0.382**	(0.192)
$\widehat{\gamma}_{PY}$	0.620**	(0.142)						
Panel C: Effects of Explanatory Variables								
constant	1.658**	(0.592)		1.584**	(0.442)		0.495	(0.345)
Y_age $\times 10^{-1}$	−0.400	(0.358)						
Y_age2 $\times 10^{-2}$	−0.184**	(0.051)						
Y_male[a]	0.038	(0.071)		0.084	(0.100)			
F_age $\times 10^{-1}$				−0.028	(0.190)			
F_age2 $\times 10^{-2}$				−0.029	(0.027)			
F_black				0.186	(0.135)			
P_age $\times 10^{-1}$							0.229**	(0.049)
P_age2 $\times 10^{-2}$							−0.015**	(0.001)
P_higher_educ[b]	0.134	(0.107)					0.026	(0.103)
P_married	−0.195*	(0.105)					0.216*	(0.107)
P_poverty	−0.050	(0.114)					0.152	(0.112)
relative_price[c]	−0.594	(0.486)		−0.717*	(0.416)		−1.012*	(0.548)

Notes: * and ** denote significance at 10% and 5% levels, respectively. The sample log-likelihood is −2244.13.

[a] Y (youth) and F (friend) are always of the same gender by the study design.

[b] The omitted education category comprises P's (parents) with a high school degree or less.

[c] The price variable is specific to place of residence and interview date.

The estimated correlations (std. errors) are $\widehat{\rho}_{YF} = -0.117$ (0.155), $\widehat{\rho}_{YP} = -0.725^{**}$ (0.084), and $\widehat{\rho}_{FP} = 0.009$ (0.074).

the youth and his or her best friend at a conventional significance level. Perhaps eating habits are formed through the dietary choices of parents, while other (e.g., risky) behaviors are potentially learned from peers.

Panel C shows estimated structural effects of the explanatory variables. We infer that given fixed consumption of fruit by the friend and parent, the youth's own consumption of fruit declines with the youth's age, as the coefficient on the quadratic age term is negative (the coefficient on the linear term is not statistically significant). Age also affects the parent's fruit intake. Specifically, the parent's consumption increases with age at a decreasing rate. It is worth noting that the discovered effects may not be the effects of age per se but may rather be cohort effects reflecting different attitudes of younger and older generations toward fruit consumption. In a cross-sectional setting such as the one in this paper, cohort and age effects are not separately identifiable. In addition, we find a negative effect of the parent's being married on the youth's consumption and a positive effect of being married on the parent's own consumption. The negative effect of the parent's being married on the youth's consumption of fruit is unexpected. Other demographic and socioeconomic characteristics do not have a statistically significant effect.

In line with microeconomic theory, the coefficients on the relative fruit price are negative, but the corresponding effects are fairly weak since the coefficients are only marginally significant at a 10% level in the cases of the friend and parent, and not statistically significant in the case of the youth.

Lastly, we find a statistically significant correlation between the errors $\epsilon_{Y,t}$ and $\epsilon_{P,t}$, which indicates the presence of the correlated effect between the youth and parent. An analysis of the robustness of the results shows that our main results remain qualitatively the same across different specifications of the model (see Appendix C).

B. Vegetable Consumption

The estimated model of vegetable consumption is presented in Table 5, which follows the layout of Table 4. Again, while Panel A shows that the thresholds are precisely estimated, our primary interest lies in coefficients in Panels B and C.

The results indicate a positive endogenous effect of the parent's consumption of vegetables on youth's consumption ($\widehat{\gamma}_{PY} = 0.586$), as shown in Panel B. We do not detect an impact in the reverse direction, since the estimate of γ_{YP} is not statistically significant, indicating the asymmetry of social interactions. Similarly to the case of fruit consumption, we do not find statistically significant endogenous effects between the youth and friend, which again suggests that eating behaviors are primarily learned from one's parents rather than peers.

Panel C shows that the effects of age are nonlinear. This result indicates that the youth's intake of vegetables declines until the youth is approximately 20 years old (given fixed intakes of vegetables by the parent and friend) but increases thereafter. The finding that the youth's consumption decreases in the late teens is consistent with Stewart and Menning's (2009) result that adolescents' propensity to eat vegetables declines with age in wave 2 of Add Health. Also, we infer that the consumption of the friend and parent increases with age at a decreasing rate. Analogously to the case of fruit consumption, these estimates may reflect cohort effects rather than the effects of age per se. The effect of the parent's being married on his or her own intake of vegetables is positive and statistically significant, but the effect on the youth's consumption is negative and not significant. It is worth noting that Stewart and Menning (2009) estimate that adolescents from two-parent households have a higher propensity to eat vegetables, which is consistent with our finding that the reduced-form impact of the parent's being married on the youth's vegetable intake (not reported in Table 5) is positive.[11] Other demographic and socioeconomic characteristics do not exert a

[11] The difference between the effect of the parental marital status in our case, and Stewart and Menning's estimate, underscores the conceptual difference between structural and reduced-form effects of explanatory variables in a model with social interactions.

Table 5: Estimated Model of Vegetable Consumption

	Youth: $w^*_{Y,t}$ Coeff.	Std. Err.		Friend: $w^*_{F,t}$ Coeff.	Std. Err.		Parent: $w^*_{P,t}$ Coeff.	Std. Err.
Panel A: Thresholds								
$\widehat{\alpha}_Y\,(3)$	0.672**	(0.134)	$\widehat{\alpha}_F\,(3)$	0.811**	(0.087)	$\widehat{\alpha}_P\,(3)$	1.140**	(0.134)
$\widehat{\alpha}_Y\,(4)$	1.489**	(0.286)	$\widehat{\alpha}_F\,(4)$	1.760**	(0.149)	$\widehat{\alpha}_P\,(4)$	2.286**	(0.214)
$\widehat{\alpha}_Y\,(5)$	1.737**	(0.331)	$\widehat{\alpha}_F\,(5)$	2.044**	(0.166)	$\widehat{\alpha}_P\,(5)$	2.547**	(0.231)
Panel B: Endogenous Effects								
$\widehat{\gamma}_{FY}$	−0.351	(0.273)	$\widehat{\gamma}_{YF}$	−0.168	(0.384)	$\widehat{\gamma}_{YP}$	−0.234	(0.386)
$\widehat{\gamma}_{PY}$	0.586**	(0.250)						
Panel C: Effects of Explanatory Variables								
constant	2.147**	(1.090)		1.204**	(0.562)		0.271	(0.413)
Y_age $\times 10^{-1}$	−1.256**	(0.057)						
Y_age2 $\times 10^{-2}$	0.319**	(0.075)						
Y_male[a]	−0.006	(0.099)		0.071	(0.095)			
F_age $\times 10^{-1}$				0.328*	(0.177)			
F_age2 $\times 10^{-2}$				−0.037**	(0.018)			
F_black				0.123	(0.119)			
P_age $\times 10^{-1}$							0.524**	(0.059)
P_age2 $\times 10^{-2}$							−0.045**	(0.002)
P_higher_educ[b]	0.052	(0.093)					0.012	(0.105)
P_married	−0.039	(0.128)					0.320**	(0.110)
P_poverty	0.006	(0.094)					−0.010	(0.122)
relative_price[c]	−1.559*	(0.902)		−1.352†	(0.839)		0.485	(0.672)

Notes: †, *, and ** denote significance at 11%, 10%, and 5% levels, respectively. The sample log-likelihood is −2152.12.

[a] Y (youth) and F (friend) are always of the same gender by the study design.

[b] The omitted education category comprises P's (parents) with a high school degree or less.

[c] The price variable is specific to place of residence and interview date.

The estimated correlations (std. errors) are $\widehat{\rho}_{YF} = 0.467^{**}$ (0.235), $\widehat{\rho}_{YP} = -0.306$ (0.207), and $\widehat{\rho}_{FP} = 0.107$ (0.132).

significant impact.

The effects of the relative vegetable price on the youth and friend are negative although both effects are fairly weak, since they are only marginally statistically significant (at 10% in the case of the youth and 11% in the case of the friend). The estimate of the price effect on the parent is not statistically significant.

Lastly, we find a statistically significant correlation between the errors $\epsilon_{Y,t}$ and $\epsilon_{F,t}$, indicating the presence of a correlated effect between the youth and friend. Our main results remain qualitatively unchanged across different specifications of the model (see Appendix C).

V. Discussion and Conclusion

We analyze determinants of fruit and vegetable consumption by African American youths focusing on the roles of social interactions and the relative prices of fruits and vegetables in the consumption of these foods by a youth, his or her parent, and a best friend. The richness of the behavioral data in the FACHS allows us to distinguish two distinct impacts on the youth's own food intake: the impact of the parent's food intake and the impact of the friend's intake. Because our sample is comparable to nationally representative samples in terms of food consumption frequencies and basic demographic characteristics, our conclusions may apply not only to African American youths in Georgia and Iowa, but also more broadly to the population of all African American youths in the U.S.

We find the presence of endogenous effects between the youth and parent in the consumption of fruits and vegetables. This result is in line with existing evidence that children's eating behaviors are affected by observing food-selection patterns of their parents (e.g., Cullen et al., 2001). Moreover, it suggests that the process of shaping eating behaviors persists beyond early childhood years into late adolescence. Most notably, the result indicates the existence of social multipliers within African American families, which would imply that a health policy intervention focusing on increasing fruit and vegetable intake by parents would also increase intake by the youths themselves, even when the youths are not direct targets of the intervention. Hence, a cost-effective strategy for designing policy interventions may be to target only one member in a family such as the mother, who is typically the primary caregiver. In turn, the lack of strong evidence regarding an impact of friend's consumption on the youth's consumption and vice versa suggests that interventions aimed at increasing consumption of fruits and vegetables by African American youths may be more effective when targeting their families than peer groups.

We also find that relative fruit and vegetable prices tend to negatively affect the intake of these foods, but the estimated price effects are statistically weak. More specifically, in this sample of African Americans, the relative price of fruit is more important for the parent's consumption than for the youth's consumption. In contrast, the relative price of vegetables tends to affect the youth's consumption, but not the parent's consumption. Given our finding of endogenous consumption effects between parents and youths, these results suggest that decreasing the relative price of fruit through subsidies may increase the intake of fruit by the parents, and because of the social multiplier effect increase the intake among the youths themselves. In turn, in the case of vegetables, decreasing the relative price of vegetables may increase their intake by the youths directly, but is unlikely to also have a spillover consumption effect on the parents.

The differential endogenous effects found in this paper may stem from a variety of reasons. For instance, eating place may be a factor. At home, parents may influence their children's consumption by purchasing fruits and vegetables to eat during family meals and for snacks. Youths and their best friends, however, may be more likely to consume food together when they are away from home and at locations in which fruits and vegetables are less readily available (e.g., at fast food locations). Thus, youths and friends may be less exposed to each other's fruit and vegetable consumption than youths and parents are.

Knowledge of how various factors affect food consumption is crucial for designing policy interventions to facilitate healthy eating by young people. Our results imply that increasing fruit and vegetable consumption through a policy intervention may be achieved by targeting the youth's primary caregiver (e.g., the mother) through programs such as the Expanded Food and Nutrition Education Program (EFNEP) or at places in which food is purchased such as grocery stores. The results also indicate that lowering the relative prices of fruits and vegetables by subsidizing these foods may also increase their consumption by African Americans.

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Appendix A Comparison to CPS

The CPS is a monthly survey of about 50,000 households conducted by the Bureau of the Census. By design, it is representative of the U.S. civilian noninstitutional population. Although the main purpose of the CPS is to collect employment data, its notable secondary goal is to obtain demographic information. The Annual Social and Economic (ASEC) Supplement to the CPS, formerly known as the March Supplement, is administered every year to collect socioeconomic information beyond basic employment and demographic data.

To explore whether characteristics of the FACHS participants are similar to characteristics of the corresponding population in the U.S., we extracted a subsample from the 2006 ASEC Supplement data file by selecting all households containing an African American youth between the ages of 17 and 21, and at least one parent (in what follows, we refer to this subsample as "the CPS subsample").[12] The CPS subsample includes 1,053 households.

Table A1 presents summary statistics for selected demographic and socioeconomic characteristics of parents in the CPS subsample. To be consistent with the FACHS design, whenever a household in the CPS subsample contains the mother (either single or married) of the youth, we use her characteristics (rather than characteristics of the father) as characteristics of the parent. Otherwise, when a household does not contain the mother, we use information on the father. All statistics are computed using the ASEC Supplement weights. We also provide z-statistics and P-values for tests of equality between respective means in the FACHS and CPS.

As can be seen in Table A1, parents in the CPS subsample are between the ages of 30 and 80, and on average are 45 years old. The parent is male in only 5% of the cases.[13] Ninety three percent of the parents are African American. Thirteen percent of them have no high

[12]More specifically, given the observed races of the FACHS youths, we selected the CPS households with youths who report their race as "African American only" or as any bi- or tri-racial combination involving "African American."

[13]Thus, there are only 5% of households with a single father in the CPS subsample.

Table A1: Characteristics of Parents in CPS Subsample

Characteristic of Parent	Mean	Std. Dev.	Min	Max	z-stat[a]	P-value[a]
Age in years	44.65	(6.68)	30	80	1.00	(0.32)
Indicator of male gender	0.05	(0.23)	0	1	−0.17	(0.87)
Indicator of African American race[b]	0.93	(0.25)	0	1	−0.68	(0.50)
Indicator of no high school degree[c]	0.13	(0.34)	0	1	2.05	(0.04)
Indicator of high school degree[c]	0.39	(0.49)	0	1	−1.96	(0.05)
Indicator of some college education[c]	0.31	(0.46)	0	1	1.49	(0.14)
Indicator of bachelor's/higher degree[c]	0.17	(0.37)	0	1	−1.46	(0.14)
Indicator of married parent	0.43	(0.50)	0	1	−2.58	(0.01)
Indicator of poverty	0.22	(0.41)	0	1	2.52	(0.01)

Notes:

The number of parents in the CPS subsample is 1,053. Statistics are computed using the ASEC Supplement weights.

[a] z-statistic and P-value refer to a two-sided test of the null hypothesis that the mean of the characteristic in the FACHS sample is equal to the mean in the CPS subsample.

[b] Four percent of parents are "White only," 2% are bi- or triracial with "African American" as one of the races, and 1% report some other race.

[c] Educational categories represent the highest level of educational attainment.

school degree, 39% have a high school degree, 31% have some college education (including an associate degree), and 17% have a bachelor's or higher degree. Forty three percent are married, and 22% live in poverty.

The tests of the equality between mean characteristics in the FACHS and CPS indicate no statistically significant difference (at a conventional level) between the two samples of parents with respect to the mean age and the gender and race compositions. We also see no statistically significant difference between the samples with respect to the fractions of parents with some college education and with a bachelor's or higher degree. However, the tests and comparison of Tables 1 and A1 reveal that the proportion of individuals without a high school degree among the FACHS parents is higher than among the CPS parents (18% vs. 13% respectively), while the proportion of high school graduates among the FACHS parents is lower (34% vs. 39% respectively). These differences are significant at the 5% level. Thus, the FACHS parents seem to have a somewhat lower educational attainment overall. Also, we see that fewer FACHS than CPS parents are married (36% vs. 43% respectively) and more FACHS parents live in poverty (28% vs. 22% respectively).[14] The latter differences are significant at the 1% level.

We conclude that basic demographic characteristics of the FACHS sample of parents are practically the same as the characteristics of the CPS subsample, except that the proportion of married parents is lower in the FACHS. However, parents in the FACHS tend to have less income and a somewhat lower educational attainment than parents in the CPS.

[14]The incidence of poverty in the FACHS sample at 28% is also higher than the incidence of poverty among all African Americans in the U.S. in 2006 at 24% (DeNavas-Walt et al., 2007, p. 47).

Appendix B Comparison to NHANES

The NHANES is a continuous program of cross-sectional studies conducted by the National Center for Health Statistics of the CDC to assess the health and nutritional status of the U.S. civilian noninstitutional population. Each year, the survey covers a nationally representative probability sample of about 5,000 adults and children. Public use data are released biannually. Starting with the NHANES 2003-2004, respondents aged two years and older who have completed a 24-hour dietary recall interview are requested to additionally fill in a food frequency questionnaire (FFQ).[15] The FFQ is administered to ascertain information on food consumption in the past year. Details on the development of the FFQ are provided by Subar et al. (2006).

We employ the FFQ in the NHANES 2005-2006 to assess whether the fruit and vegetable consumption patterns of the FACHS Wave 4 participants are in line with the NHANES respondents' consumption habits, which are representative of the habits of the U.S. population. Since the underlying food frequency questions in the FACHS and NHANES are phrased differently, we only provide a comparison of the patterns rather than perform a formal test of whether they are identical.

To obtain the fruit consumption patterns in the NHANES, we use answers on drinking various fruit juices and eating various fruits (a total of 15 distinct answers). Records with missing answers are dropped. The fruit juice drinking responses are recorded in ten separate categories (from "never" to "6 or more times per day" in the past year), while fruit eating answers comprise eleven categories (from "never" to "2 or more times per day" in the past year). We convert each answer into a weekly frequency using the midpoint of a corresponding response range. For example, if a respondent ate apples "1-6 times per year," we convert this frequency to $\frac{1+6}{2} \cdot \frac{7}{365} \cong 0.067$ times per week. The conversion to the weekly frequency is done for comparability with the FACHS. Next, we sum the imputed weekly frequencies across the

[15]Prior to 2003, the NHANES regularly included food frequency questions, but they varied in terms of the food group specificity, reference period, and so forth.

Table B1: Fruit and Vegetable Consumption in FACHS and NHANES

	17-21 y.o. African Americans		30-69 y.o. African Americans	
	FACHS (Last week)	NHANES (Typical week)	FACHS (Last week)	NHANES (Typical week)
Panel A: Fruit consumption				
Less than once a day, %	39.35	33.01	34.85	39.01
Once a day or more, %	60.65	66.99	65.15	60.99
(Subsample size)	(826)	(173)	(462)	(430)
Panel B: Vegetable consumption				
Less than once a day, %	40.56	37.00	24.03	25.01
Once a day or more, %	59.44	63.00	75.97	74.99
(Subsample size)	(826)	(173)	(462)	(437)

Note:

Statistics for the NHANES subsamples are computed using the FFQ sample weights.

questions. If this sum is less than seven, the NHANES respondent is deemed to consume fruit less frequently than once a day in a "typical" week in the past year. Otherwise, his or her fruit consumption frequency is once a day or more. Analogously, we obtain the vegetable consumption patterns from 21 distinct vegetable eating questions in the FFQ. Using only two broad frequency categories – "less than once a day" and "once a day or more" – rather than narrower categories may help reduce sensitivity of the comparison to the imputation error.

Table B1 presents the fruit and vegetable consumption patterns in the FACHS along with the imputed patterns in the NHANES 2005-2006.[16] Given the distribution of age and race in our FACHS sample (Table 1), we focus on two separate subsamples in the NHANES: (non-Hispanic) African Americans ages 17-21, and African Americans ages 30-69. All subsample frequencies in the NHANES are computed using the FFQ sample weights.

[16]The FACHS frequency responses "none" and "less than once a day (1-6 times)" are grouped together as "less than once a day," while the responses "once a day," "8-12 times," and "twice a day (or more)" are grouped as "once a day or more."

As can be seen in Table B1, among African Americans ages 17-21 in our FACHS sample, approximately 39% ate fruit or drank fruit juice less frequently than once a day in the last week before the interview and the remaining 61% consumed fruit once a day or more often. In comparison, among African Americans ages 17-21 in the NHANES, 33% consumed fruit less than once a day in a typical week in the past year, while 67% did so once a day or more often. It is easy to compute that the difference between the corresponding fractions in the FACHS and NHANES in relative terms is within 9.5% ($\cong \frac{6.34}{66.99} \cdot 100\%$) to 19% ($\cong \frac{6.34}{33.01} \cdot 100\%$). We see even smaller differences between the vegetable consumption patterns of African Americans ages 17-21 (6% to 10% in relative terms) and fruit consumption patterns of African Americans ages 30-69 (6% to 12% in relative terms). The difference between the vegetable consumption patterns of African Americans ages 30-69 is particularly small (1% to 4% in relative terms).

The comparison indicates that the difference between the fruit and vegetable consumption patterns in the FACHS Wave 4 and NHANES 2005-2006 is qualitatively small. Thus, the food consumption habits of the FACHS participants appear to be in line with the habits of the corresponding U.S. population. However, it is important to note that our comparison is only suggestive rather than definitive because it is not possible to perform a formal test of whether the consumption patterns in the FACHS and NHANES are identical.

Appendix C Robustness Analysis

We estimated several alternative specifications of the empirical model to check the robustness of our findings.[17]

First, we replaced the relative price indices with "raw" price indices, that is, the expenditure weighted averages of prices of the fruit and vegetable groups in the QFAHPD. In the case of fruit, we find little difference from the results with the relative price measures. The new estimates of the endogenous effects between the youth and parent are still positive and statistically significant, while the ones between the youth and friend remain insignificant. There are a few minor changes in the magnitude and significance of the constant terms and age terms. However, we still find that the youth's consumption decreases with age, while the consumption of the parent increases with age. The coefficients on the parental marital status are practically unchanged. As before, all other demographic and socioeconomic characteristics do not have a statistically significant impact, and estimates of the correlations among the errors indicate the presence of a correlated effect between the youth and parent. Most notably, we find a statistically significant negative effect of the "raw" fruit price index on the parent's consumption and marginally significant (at 11%) negative impact on the friend. The coefficient on the price faced by the youth is negative but not significant.

The results for vegetable consumption tend to be slightly more sensitive to the change in the price variables, but we still find many similarities. As before, we estimate a positive and significant endogenous effect of the parent's consumption on the youth's consumption and no effect in the reverse direction. The endogenous effects between the youth and his or her friend remain insignificant. There are a few small differences in the magnitude of coefficients on the constant terms and age terms. We still find that the consumption of the youth declines in the late teens, but the estimates no longer imply that it increases after age 20. As before, the friend's consumption tends to increase with age at a decreasing rate.

[17]Numerical estimation results summarized in this appendix are available from the authors on request.

Likewise, the parent's consumption tends to increase with age at a decreasing rate. The impact of the parent being married on his or her own intake of vegetables remains positive and significant. The coefficients on all other demographic and socioeconomic characteristics remain insignificant. There are a few changes in the significance of the estimated correlations among the errors (namely, the estimate of ρ_{YF} loses significance, while the estimate of ρ_{YP} becomes significant at the 10% level), but the direction of every correlation is unchanged and the magnitude of the difference from the previous results is small. Most notably, we do not find the "raw" vegetable price to exert a significant impact on vegetable intakes of triplet members. Perhaps the corresponding effects are statistically weak and our sample size is insufficiently large to estimate them precisely. It is more likely, however, that the specification with the "raw" prices is too crude to correctly capture price effects, since it ignores prices of substitute goods. Therefore, we believe that the results with the relative price are more informative.

Second, we re-estimated the models while excluding quadratic age terms. Apart from minor changes in the magnitude and significance of the estimates, the results are similar to the ones with quadratic age terms included. In the case of fruit, we find that the youth's consumption declines with the youth's age, while the parent's consumption increases, which is broadly in line with the earlier findings. We also obtain slightly larger estimates of the endogenous effect of the friend on the youth and of the friend being African American. In addition, the estimate of the effect of the relative price faced by the friend becomes marginally insignificant. All other results are practically unchanged.

In the case of vegetables, we find that the friend's consumption and parent's consumption increase with age, which is broadly consistent with the earlier estimates. As before, we find that the youth's consumption decreases with age, but the corresponding estimate becomes insignificant.[18] Also, there are some changes in the significance of the correlations among the

[18] A likelihood ratio test rejects the null hypothesis of no quadratic age effects at the 1% level. Thus, the insignificance of the estimate may have resulted from the incorrect

errors (the estimate of ρ_{YF} loses significance, while the estimate of ρ_{YP} becomes significant at the 10% level), but the change in the magnitude of the correlations is negligible. All other results are practically unchanged.

Third, a small number of the FACHS respondents were interviewed in 2007 for which no comparable price data are available in the QFAHPD. Previously, instead of dropping these observations, we merged all FACHS records from 2007 with the price data from the fourth quarter of 2006. Such imputation may introduce errors in the price variables. Thus, we re-estimated the models while excluding all triplets with imputed prices from the sample (there are eight such triplets, which leaves a total of 494 triplets to re-estimate the models). We find that the results remain practically unchanged after the exclusion.

Lastly, we were surprised to find no impact of parental education on the consumption of fruits and vegetables. To check whether this result may be due to our specification of the two education categories (high school degree or less vs. some college with or without a degree), we estimated versions of the empirical model with two different education categories (namely, some college without a degree or less vs. bachelor's or higher degree), as well as with four categories (no high school degree, high school degree, some college but no bachelor's degree, and bachelor's or higher degree). The coefficients on education indicators remain insignificant. Perhaps the sample size is insufficiently large to estimate the impact of education precisely.

To conclude, the additional analyses indicate that the main results reported in the paper are, overall, robust to changes in the specification of the empirical model and are not substantially affected by limitations of the available data.

specification.